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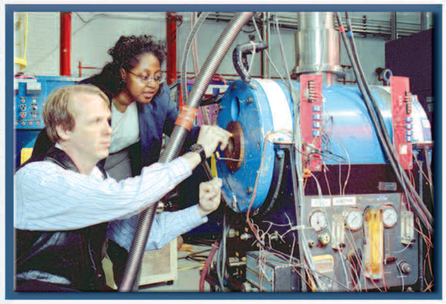

Stewardship of Capabilities

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Stewardship of Capabilities

Ships & Ship Systems NotePAD

By Charles (Randy) Reeves

Our theme for this issue is "Stewardship of Capabilities." We look closely at this stewardship of our resources, both people and facilities, so that we can effectively answer the demand for new technologies and also sustain those areas of competency needed to deliver the best services and products to our customers. Stewardship of technical capabilities is a major objective in our product area and the Warfare Center integrated planning process.

As a first step, we initiated a technical health assessment (THA) to fully examine our stewardship goals. This tool allows us to better understand the essential competencies, knowledge levels, and facilities that make up the product area. We started our assessment using a broad scope and looked at our core equities. We then narrowed the focus to technical capabilities, to knowledge areas, and finally to individual people and facilities. One of the reasons we perform health assessments is to understand who and what we have, and who and what we need in terms of technical expertise and critical facilities. The THA is discussed in more detail on page 2.

NAVSEA headquarters employs the Human Capital Digital Dashboard (HCDD), a web-based application that provides graphical representation of organizational data which documents enterprise expertise associated with technical warrants, deemed critical to the technical certification of Navy design efforts. This tool enables NAVSEA's leadership and technical authorities to quickly determine the health of their required capabilities, assess leadership abilities, mission capability, and technical documentation health and locate the engineers across the enterprise assigned to these functions. Utilizing these two metric tools enables us to evaluate the strengths of our technical resources more effectively and efficiently.

In some cases, we are stewards of traditional knowledge areas and facilities, and in other cases, we steward the development of new technical capabilities. The more traditional capabilities are highlighted in the Propulsor Design and Evaluation article, found on page 6, while emerging capabilities are discussed in the Integrated Power Systems (IPS) article on page 8. As depicted in the Propulsor Design and Evaluation article, the tradition of excellence and our recognition as an industry standard have helped us excel in the more historical standards of ship design. Conversely, the IPS article discusses the land-based test site constructed at Carderock Division's Philadelphia site to help develop these new capabilities as we transition to all-electric ships. As we move toward these integrated power systems, we recognize a growing need to understand and nurture the capabilities required to fully utilize that new technology. As a result, we are investing in advanced electrical engineering degrees to help the Navy better leverage the benefits of integrated power systems.

It is one of the Warfare Center's responsibilities to be the "pipeline" of engineering resources for the Navy of the future. As a steward of engineering, we must not only sustain current capabilities but plan for the future through hiring, training, and mentoring the next generation of engineers. We must accomplish this while working closely with our customers to ensure that the needs of the Navy are met.

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On the Cover: The Ships and Ship Systems Product Area is committed to sustaining the Navy's technical capabilities for the future. The cover images focus on mentoring young engineers at Carderock and Port Hueneme Divisions who will serve as the pipeline of engineering resources for the Navy. Photos and renderings provided by NSWC Carderock and Port Hueneme Divisions.
Cover design by Gloria Patterson.

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S3 BUSINESS

Technical Health Assessment

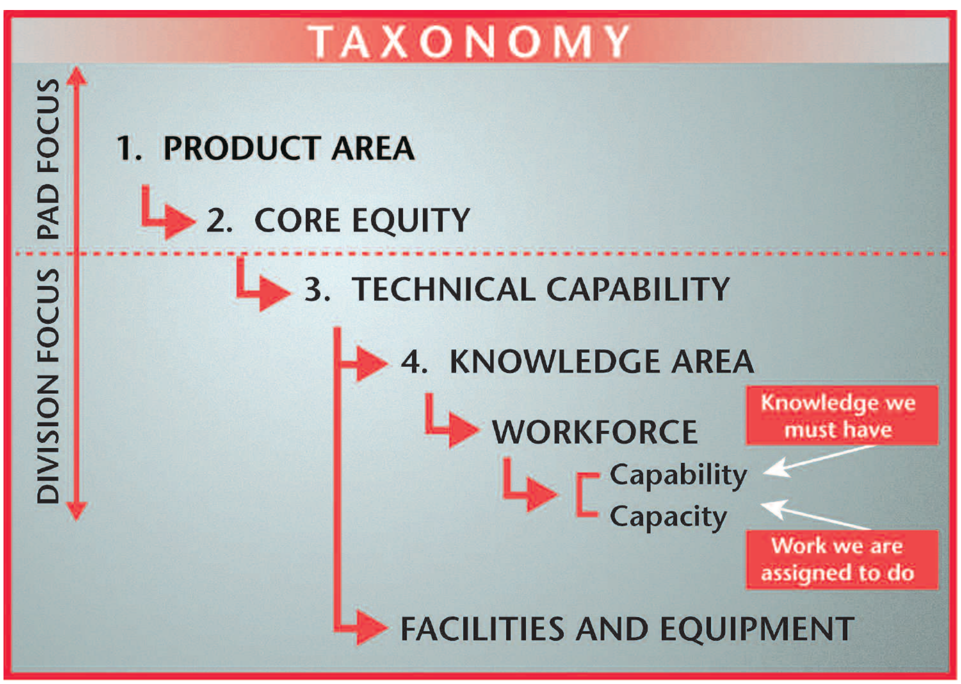
The Story Behind the Numbers

By Arnold Ostroff and Daniel Dozier

One of the critical issues that our senior leadership faces every day is "can we sustain the technical capabilities that the Navy needs now and in the future?" By focusing on the two elements that give us the *capability* and *capacity* to perform work–our people and our facilities–and this question of sustaining technical capability, we've developed a common model for performing the analysis and assessment of the health of our workforce, called the Technical Health Assessment (THA).

"Why do we have the number of people working in a particular technical area that we do?" The answer to this question is very complex. Certainly, what our customers expect of us is a major factor, but there are other considerations. In addition to the easy answer of customer demand, the number of people in a technical area also depends upon the level of expertise required of the work-force, the technical complexity of the work and need for special-ization among the workforce, the number of people needed in the "pipeline" to replace projected vacancies, the cyclical nature and long-term prospects of the work, and the appropriate mix of government personnel vs. non-government personnel to perform the work.

The THA was initiated by the Ships and Ship Systems (S^3) Product Area Director (PAD) in 2004 and has been refined and implemented as a joint effort between the S^3 PAD and the Carderock Division. It strives to answer the above questions by addressing two different aspects of our work–the knowledge base required for sustaining the capability to perform the work and the ability to have sufficient workforce capacity to execute it. Each of these takes on a special significance to the PAD and the Division. The PAD is responsible for sustaining critical capabilities within the product area, and is most interested in the health assessment's ability to define the essential competencies and levels of knowledge comprising the product area. The Division, on the other hand, is responsible for executing the work assigned and is most concerned with understanding how well its work-force can support current and future workload demands and in making workforce decisions shaping the Division's future.



TAXONOMY EXAMPLE

LEVEL 1. PRODUCT AREA

Ships and Ship Systems

LEVEL 2. CORE EQUITY

Signatures, Silencing Systems, and Susceptibility

LEVEL 3. TECHNICAL CAPABILITY

Active and Passive Acoustic Signatures and Silencing Systems

LEVEL 4. KNOWLEDGE AREA

Hydroacoustics Research and Engineering

LEVEL 5. COMPETENCIES

- *Expertise in the physics of turbulent flow*
- *Expertise in physics of fluid-structure coupling*
- *Understanding the physics of radiation from flow . . .*
- *Ability to analyze ship signatures . . .*
- *Knowledge of current ship acoustic requirements . . .*
- *Ability to recommend full-scale design features . . .*
- *Familiarity with current developments in advanced theoretical . . .*
- *Ability to conduct basic and exploratory research efforts . . .*
- *Ability to develop innovative and novel solutions to mitigate . . .*
- *Ability to develop new predictive tools based on analytical and . . .*

Information for the THA is collected within a hierarchical taxonomy, or classification, starting with *core equities* (the S^3 Product Area has seven), then at the *technical capabilities* level (the Carderock Division has 21) and finally at the *knowledge area* level (the Carderock Division has more than 450). A *knowledge area* is defined as "a characterization of unique roles, abilities, or areas of expertise that reside in a small work group to enable fulfillment of a *technical capability*." Each *knowledge area* has a number of competencies that fully describe the knowledge that experts need to have. Data are collected at the *knowledge area* level to answer the following three questions: (1) Is there a sufficient minimum number of trained and experienced personnel to sustain the *knowledge area* that the U.S. Navy needs? (2) Is there sufficient funding to sustain the minimum capability needed for the *knowledge area*? (3) Can the workforce supply fulfill the total customer demand as assigned (or projected in the future) by a PAD?

The THA is useful in identifying workforce assignments, deficiencies, and surpluses. It was used in 2005 and 2006 to justify hiring decisions and can provide information for requests from higher authority about workforce deployment and sufficiency. By linking health assessment data to other management information systems, we can facilitate training and reassignment decisions and better understand how well the workforce can support future requirements. Recently, the THA was used to describe the Carderock Division's required minimum workforce to perform early stage submarine design for an ongoing RAND study exploring sustainment issues.

In 2005, the Warfare Center initiated an effort to develop a Capabilities Assessment model for all of its divisions to understand the collective workforce and to answer many of the same questions we were addressing. Because the S^3 PAD and the Carderock Division had already developed and tested a robust THA model, it was used as the starting point for the entire Warfare Center model. The adaptation has been very successful to date, and we expect to see our Technical Health Assessment model imbedded in the common Warfare Center model later this year.

Finally, in addition to assessing the health of our workforce, we also need to assess the health of our facilities. In 2005, we started to develop a Facilities Health Assessment model. This model was developed to assist our leadership in making appropriate investment decisions on our facilities to sustain them into the future. The model addresses the PAD perspective of retaining the technical capabilities of facilities to be able to perform work that is required now and in the future. It also takes into account the ability of the divisions to afford to operate and sustain the facility to conduct that work. The model looks at two broad aspects of facilities–capabilities and business health. A facility's capability includes its operational characteristics and its readiness. A facility's business health refers to its economic viability, i.e., how well can we recover costs associated with its operation and maintenance from sponsors and its utilization. Again, because of our joint leadership in the development of this tool, our Facilities Health Assessment model will be the basis for the 2006 Warfare Center Facilities Health Assessment model.

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Ship Integration & Design

Roll-On/Roll-Off Sea Basing Initiatives

Engineers Investigate Use of Cranes to Support Underway Vehicle Transfers

By William Palmer

Carderock Division researchers supporting the Ships and Ship Systems (S^3) Product Area (PA) recently teamed with several corporate and government groups to demonstrate ship-to-ship transfer of vehicles at sea. S^3 PA engineers participated in an at-sea experiment sponsored by the Maritime Prepositioning Force (Future) [MPF(F)] program office (PEO Ships, PMS 325) to demonstrate the concept of a Mobile Landing Platform (MLP). The MLP is envisioned as the "pier in the ocean" for the MPF(F). It will allow Large Medium Speed Roll-On/Roll-Off (LMSR) ships to transfer rolling stock, cargo, and personnel onto its deck for further transfer via Landing Craft Air Cushion (LCAC) to shore. With a threshold requirement of conducting vehicle transfers in sea state 3 (four-foot average wave height), a ramp is envisioned as the transfer mechanism between the ships to meet throughput requirements. While much work was conducted during the experiment to acquire data and further knowledge about side-by-side, or "skin-to-skin" transfers at sea, additional study is necessary to refine the concept.

Figuring prominently in refining the use of vehicle ramps at sea is the development of the Pendulation Control System (PCS). The PCS minimizes uncontrolled swings of shipboard crane payloads caused by wave-induced ship motions. In 2003, two T-ACS ships, assigned to the Maritime Administration, participated in an exercise demonstrating underway "skin-to-skin" operation and used a PCS-equipped crane to transfer cargo between the ships. S^3 PA engineers are focusing new effort on the PCS to make the transfer of the current LMSR ramp between the LMSR and MLP a safe and controlled evolution.

This Large Medium Speed Roll-On/Roll-Off (LMSR) vessel has a vehicle ramp rigged to a commercial semi-submersible heavy-lift ship. The heavy-lift ship is acting as a surrogate for a Mobile Landing Platform (MLP). Two Landing Craft Air-Cushions (LCACs) are positioned on the surrogate MLP's port side. *Photo courtesy of PEO Ships (PMS 325).*

The vehicle ramp is lowered into position by cranes onboard the LMSR ship. Current seabasing efforts are focusing on the use of ramps to transfer vehicles between ships to meet throughput requirements. S^3 PA engineers are examining Pendulation Control System (PCS) equipped cranes to enable ramp transfers in greater sea states.
Photo courtesy of PEO Ships (PMS 325).

The PCS was developed under an Office of Naval Research advanced technology demonstration. The system minimizes payload swings by using computer control of the crane's movements. It combines data from ship motion and crane position sensors to automatically move the crane to compensate for ship motions and reduce load swing. The system's capabilities are currently being expanded to allow for underway and twin crane operations that would support the transfer of a LMSR vehicle ramp onto a MLP in sea state 3 conditions. In addition, a Human/Hardware In-the-Loop simulator is being used to train operators and run feasibility scenarios for various combinations of ship positions and environmental factors.

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Ships and Ship Systems Technology Symposium

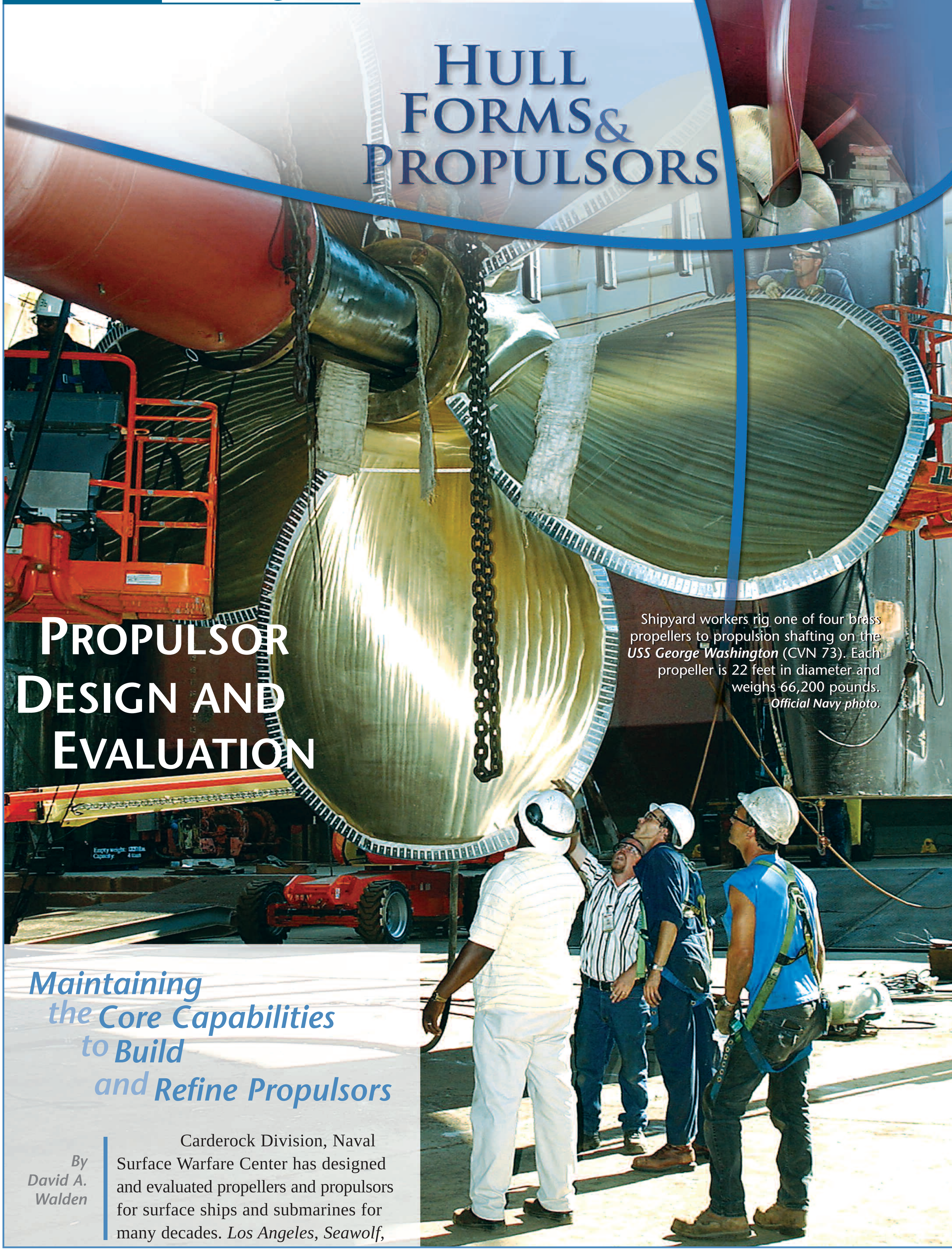
"Changes, Challenges, and Constants"

By Geraldine Yarnall

The Ships and Ship Systems (S^3) Technology Symposium was re-scheduled for November 13 through 14, 2006, at the Maritime Technology Information Center, West Bethesda, MD. This is a national forum sponsored by the American Society of Naval Engineers and supported jointly by Naval Surface Warfare Center, Carderock Division, and the S^3 Product Area (PA) Director of the Naval Sea Systems Command.

The theme for the S^3 Technology Symposium is "*Changes, Challenges, and Constants*" with a focus on the core equities that define the S^3 PA. These core equities are Ship Integration and Design; Hull Forms and Propulsors; Machinery Systems; Structures and Materials; Environmental Quality Systems; Vulnerability and Survivability Systems; Signatures, Silencing Systems, and Susceptibility. Twenty-four papers were selected for presentation. Delores Etter, Assistant Secretary of the Navy for Research, Development and Acquisition was invited as the keynote speaker. For more information on this symposium visit www.navalengineers.org.

HULL FORMS & PROPULSORS



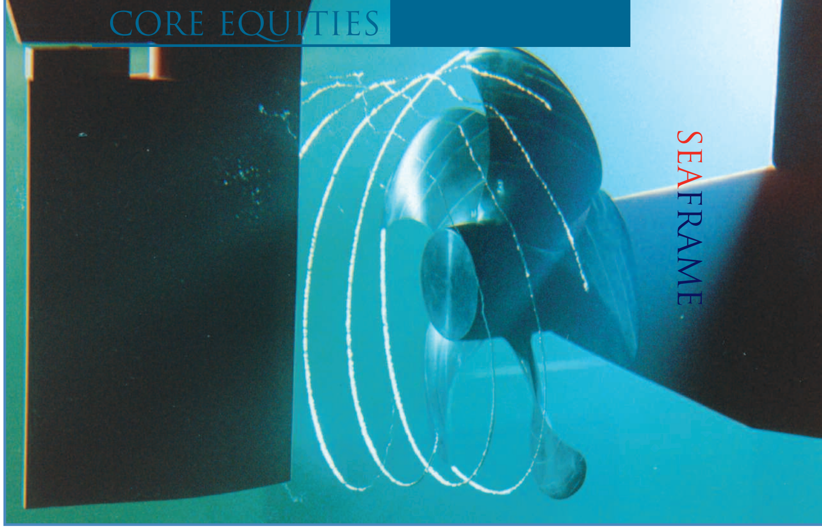
Shipyard workers rig one of four brass propellers to propulsion shafting on the ***USS George Washington*** (CVN 73). Each propeller is 22 feet in diameter and weighs 66,200 pounds. ***Official Navy photo.***

PROPULSOR DESIGN AND EVALUATION

Maintaining the Core Capabilities to Build and Refine Propulsors

By David A. Walden

Carderock Division, Naval Surface Warfare Center has designed and evaluated propellers and propulsors for surface ships and submarines for many decades. *Los Angeles*, *Seawolf*,



Time, effort, and budget money has been invested in the expertise for which Carderock Division is now internationally known. The Division is working hard to maintain its national investment in this capability. *Photo by Peter Congedo, NSWC Carderock Division.*

and *Virginia* Class submarine propulsors have their origins within Carderock Division, as do propellers for the DDG 51, CVN, FFG 7, PC 1, and AO 177 Classes, as well as other surface ships. Innovations such as highly skewed propellers and anti-singing edges, developed largely at the Division's West Bethesda site, have become an industry standard in military and commercial ships. This proud history results from the pull of aggressive acquisition programs with increasingly stringent performance requirements and the push of a technology base from the Office of Naval Research. Today, a combination of factors has challenged our ability to maintain the competencies necessary to provide government-furnished propulsors to the fleet. Because the Naval Sea Systems Command technical authority mandates that the government retain the ability to design and evaluate propulsors, including those developed by private contractors, Carderock Division is working aggressively to maintain the required capabilities.

As the Navy has delegated ship design to the shipbuilders and as core funding from the Office of Naval Research has been directed to other priorities, the combined effects of the loss of the technology base push and acquisition program pull have challenged Carderock Division to find ways to maintain the necessary skills to perform this work, which is accomplished under the Ships and Ship Systems Product Area.

In the initial comparison of core competencies and available work, a review quantified which disciplines were being adequately practiced and which were not. Planners considered why certain work areas were not currently well funded. Possible reasons included a general unawareness of work areas that were falling behind. The Division had never examined its workload so thoroughly in terms of key skills.

In response, the Propulsion and Fluid Systems Division reorganized into three teams, centering around the three major disciplines that are necessary to design and evaluate propulsors: designers, experimentalists, and computational fluid dynamicists. The leaders of each team are specifically tasked with ownership of core work areas, focusing on whether they are performing appropriate work in each discipline that is considered to be core. They must constantly reassess whether new technology and more modern approaches can replace areas that were previously considered to be core.

As a way to maintain skills, this Division identified ways to expand the base of sponsors. For example, Carderock Division, and indeed the Navy, does not have a long history with waterjet propulsors. However, multiple acquisition programs turned to waterjet propulsors as a method to achieve higher ship speeds. At the same time, ONR is investing in waterjet research.

Another way is potential partnerships with the Naval Undersea Warfare Center and the Applied Research Laboratory at Pennsylvania State University (ARL/PSU) in the area of unmanned underwater vehicles (UUVs) or torpedo propulsion. ARL/PSU is a Navy University Affiliated Research Center (UARC). The Carderock Division and ARL/PSU have a long history of collaboration in the development of submarine propulsors. Concepts and tools developed for submarine propulsion are being reviewed to determine whether they offer possibilities to meet requirements being set for UUVs and torpedoes.

Carderock Division holds the experience and expertise to design propulsors with unmatched capabilities. Many years of efforts and hundreds of millions of dollars in test facilities, computer software, research and development, and design practice have been invested. In this time of national rethinking of the acquisition strategy for ships and submarines, Carderock Division is actively working to maintain its stewardship of the national investment in this design and evaluation capability.

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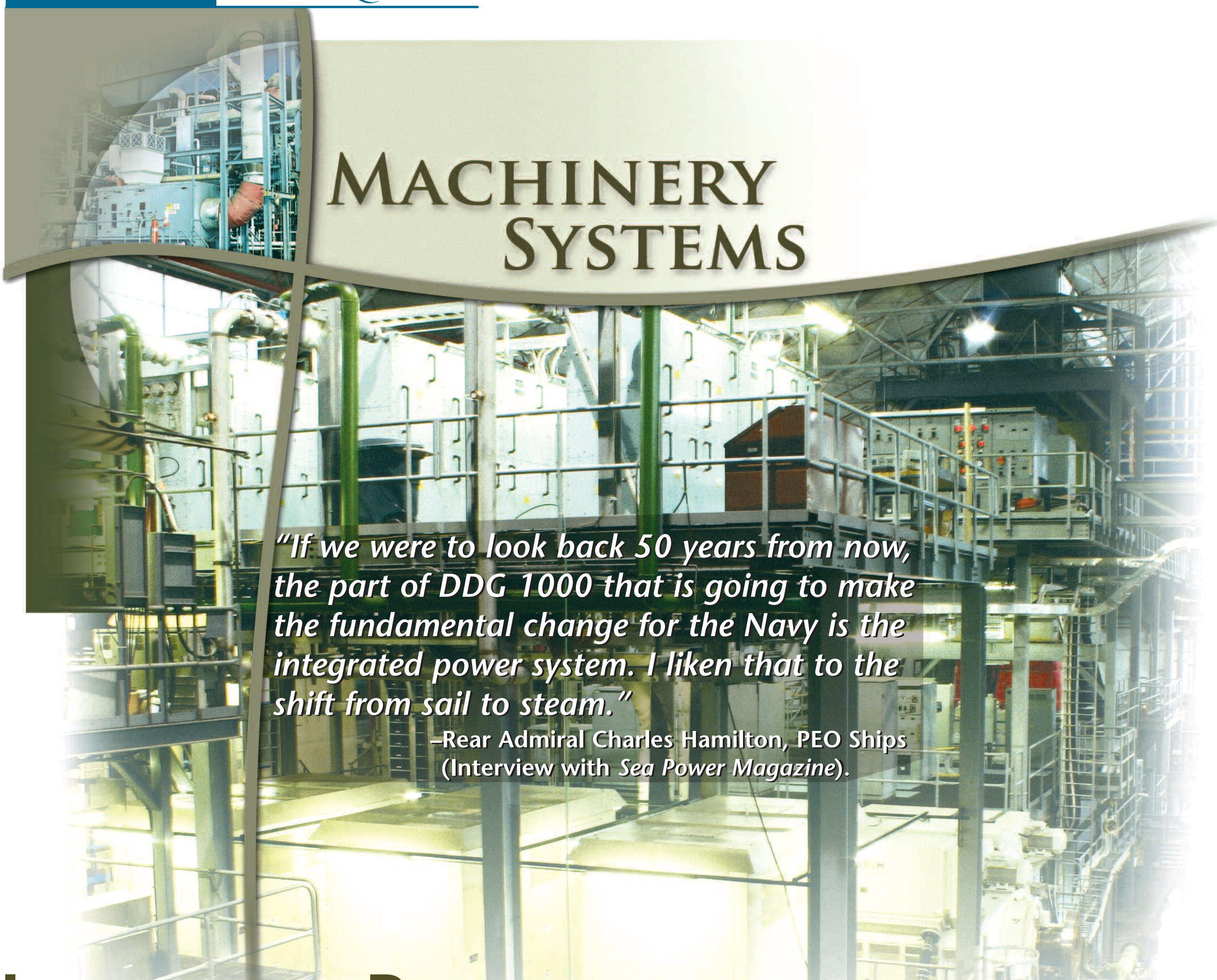
MACHINERY SYSTEMS



"If we were to look back 50 years from now, the part of DDG 1000 that is going to make the fundamental change for the Navy is the integrated power system. I liken that to the shift from sail to steam."

–Rear Admiral Charles Hamilton, PEO Ships (Interview with *Sea Power Magazine*).

The Navy's LBTS for the DDG 1000 IPS EDM replicates half of the DDG 1000's design, permitting full testing, under load, for all IPS components. The IPS EDM is an important factor in the Navy's risk-mitigation strategy and cost-control efforts.
Photo courtesy of Gordon I. Peterson, Naval Forces Magazine.

INTEGRATED POWER SYSTEMS FOR DDG 1000

Testing Critical Propulsion Technologies for the Future

By Matthew Stauffer and Michael Iacovelli

The DDG 1000 (formerly DD(X)) is designed for land attack and inland support of joint and coalition forces. It allows the Navy, working with the U.S. Marine Corps, the Army, and special forces, to meet operational requirements ashore and counter projected threats from the air, surface, and underwater, as well. Among the multitude of revolutionary capabilities offered by this family of ships is the Integrated Power System (IPS)–a capability which came one step closer when engineers supporting the Ships and Ship Systems (S^3) Product Area (PA) at Carderock Division in Philadelphia completed testing on an IPS Engineering Development Model (EDM) in 2005. Deployment of IPS will not only support the current DDG 1000 baseline design but will enable the future U.S. Navy goal of electrification of auxiliary systems. This will replace hydraulics and pneumatics, reducing maintenance and increasing system reliability. IPS is also a key enabler for future high-energy weapons such as the electromagnetic gun.

Through the ship's control and power management (C&PM) system, the IPS uses power generated by the prime movers and distributes it however it is needed. If power is needed primarily for ship's speed, power can be allocated to the propulsion system. If a weapons system requires more power, the C&PM can dynamically and autonomously reallocate power for that system. Current Navy ship designs segregate power between the main turbines used for propulsion and the auxiliary turbines that are used for everything else. IPS makes available any configuration, and this also improves fuel economy. The control system is a key enabling technology for IPS, and S3 Machinery Systems Core Equity personnel are working with industry to develop the appropriate algorithms and software to ensure that the IPS performs properly. This software will be tested at the Land Based Test Site (LBTS) in Philadelphia in conjunction with the DDG 1000 software releases.

The potential that IPS brings for future high power weapon systems is revolutionary. Advanced weapons could possibly make use of the electricity that is configurable by IPS. The Navy's Directed Energy and Electric Weapons Program Office, PMS 405, is investigating taking advantage of this capability for directed lasers, microwaves, and the aforementioned electromagnetic rail gun. The rail gun would use electricity to propel a projectile with more kinetic energy than conventional projectiles. IPS also enables the use of electric propulsion motors that have a lower acoustic signature than is possible with a mechanical propulsion system improving the ships' stealth capabilities.

The DDG 1000 IPS EDM is one of ten EDMs developed by PMS 500. The EDMs were designed to reduce development and production risks for the critical technologies planned in DDG 1000. The IPS EDM consists of roughly one-half of the ship's power generation, medium- and low-voltage distribution, propulsion, and supervisory control and power management system. Specifically, installed hardware includes a 36-megawatt (MW) main turbine generator (MTG), two 4-MW auxiliary turbine generators (ATGs), four 13.8-KVAC medium-voltage (MV) switchboards, a two-zone integrated fight through power (IFTP) low-voltage power conversion and distribution system, a 18.25-MW advanced induction motor (AIM), and associated motor drives.

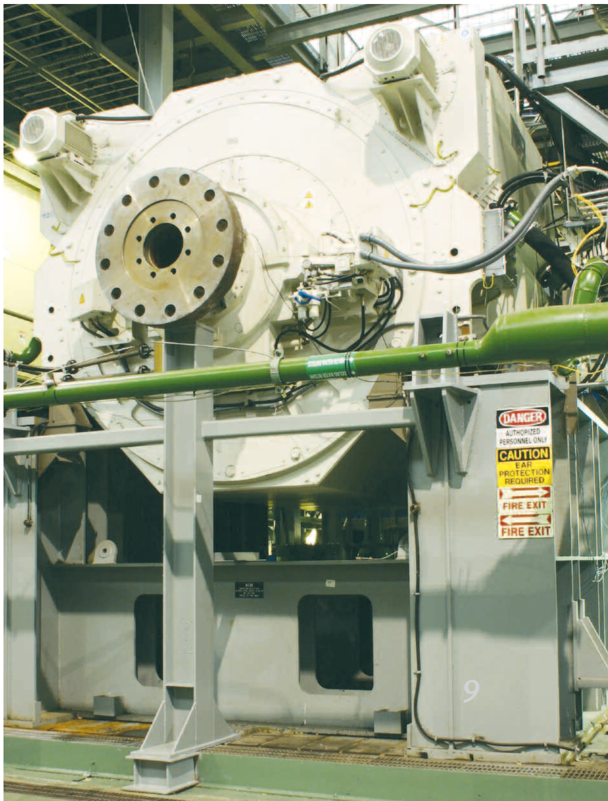
Design of the IPS EDM was initiated after the award of the DDG 1000 Phase III contract in August 2002. Most of the major components arrived at the IPS LBTS in the second and third quarters of FY 05. This led to a very aggressive schedule for equipment installation, checkout, commissioning, and system integration. Although all of the components had undergone some level of factory testing, some of the major pieces of equipment hadn't been fully integrated. For example, the MT30 gas turbine for the MTG was operated up to full-rated power at a Rolls Royce facility in the United Kingdom. The MTG generator was tested to IEEE 115 standards at its manufacturer, Curtis Wright EMD, in Pittsburgh, PA. The two units were then shipped to a DRS Technologies facility in Fitchburg, MA, where they were packaged as the entire MTG. Although the gas turbine and generator were mechanically coupled at DRS, the MTG wasn't operated as an integrated unit until after installation at the LBTS in the third quarter of FY 05. Likewise, the advanced induction motor and drives had undergone factory tests individually but were not fully integrated until being installed at the LBTS.

Following commissioning of major components, the focus shifted to completion of critical testing required to support the DDG 1000 Critical Design Review (CDR) in mid-September 2005. Specifically, completion of two developmental test (DT) events was required. The events were propulsion motor rated torque at rated speed and MTG fuel consumption at the ship's endurance load. Components involved in this test evolution were the MTG, AIM, two of the four MV switchboards, IFTP, and some additional applied electrical load from the adjacent DDG 51 Land Based Engineering Site (LBES). Initially, the AIM was commissioned using utility electricity to low power levels, and the MTG was commissioned up to about 6MW with IFTP and DDG 51 LBES load banks. This reduced the risk of the next step of the process, integrating the MTG and AIM. This event first took place on August 22, 2005. The DT events were completed on August 30, 2005–just seven operational days later. This was considered an extremely successful integration and test effort allowing the DDG 1000 Program to successfully conduct CDR, proceed to Milestone B, and then proceed to the next phase of the program–detailed design and construction.

Subsequent to completing the DT events, focus shifted to the remainder of the system integration tasks. The primary focus of these efforts was paralleling the MTG with both ATGs individually. With a nearly 9 to 1 power rating difference between the units, proper load synchronization, load sharing, and

INTEGRATED POWER (Continued on page 11)

The U.S. Navy has selected the Alstom 36-megawatt advanced induction motor, shown here at the DDG 1000 Integrated Power System Land-Based Test Site, to provide ship propulsion.
Photo courtesy of Gordon I. Peterson, Naval Forces Magazine.



MACHINERY SYSTEMS

SEA BASING UNDERWAY REPLENISHMENT

Underway replenishment sustains the fleet to patrol or fight as long as necessary. *Photo provided by NSWC Port Hueneme Division.*

Staging the Sustaining Marine Corps Operations from the Open Ocean

By Marvin O. Miller

Sea basing will use ships in the open ocean as an alternative for the lack of a nearby friendly port and airfield. Concepts are proposed for transferring Marines to ships carrying their equipment and for sustaining operations ashore and for medical evacuation of wounded Marines.

The Maritime Prepositioning Force (Future) (MPF(F)) consists of the sea basing ships that will support the alternative staging and sustainment missions. These ships will operate underway over the horizon in the open ocean, and underway replenishment (UNREP) will be crucial to their mission. The MPF(F) ships will be designed to allow sufficient space onboard to assemble the weapons and aircraft while the ships transition to the operational area.

SEA BASING STAGING

A concept is proposed for transporting Marines from the Advance Base to their Sea Base ships. At the Advance Base, Marines would board high-speed vessels (HSV) to go to the Sea Base. Transferring the Marines from the high-speed vessels to the Sea Base ships in the open ocean can be conducted by vertical replenishment (VERTREP) helos or by UNREP using a tensioned wire rope personnel transfer rig.

The current UNREP system can safely transfer loads up to 5,700 pounds in sea state 5 conditions. Today, one or two personnel are transferred at a time by this tensioned wire rope system. To meet the sea basing requirement, personnel up to the load limit of the current system could be transferred at one time. Under the Ships and Ship Systems (S^3) Product Area (PA), engineers at Port Hueneme Division previously experimented with a six-man chair and consider a chair to hold 10 Marines and their gear feasible for the Sea Base mission. A transfer rate of up to 300 Marines per hour per rig is considered achievable.

SEA BASING SUSTAINMENT

Sustaining operations ashore indefinitely from the Sea Base ships will introduce new applications of the art and science of underway replenishment. All combat logistics force (CLF) ships can refuel surface ships including friendly nations' ships. The T-AOE and T-AE (and soon T-AKE) CLF ships only carry air-launched ordnance and ship-launched ordnance for the Carrier Strike Groups. The MPF(F) ships will need Marine Corps fuel, ordnance, and stores for sustaining the landing force operations. The Carrier Strike Groups, which will also be part of the Sea Base, will continue to need its current type and quantity of sustainment. More CLF ships will be required for sea basing and three new T-AKEs will be included in each MPF(F) squadron to sustain Marine Corps ordnance and stores requirements. Refueling capability will also be required from Navy oilers or commercial tankers with UNREP fuel delivery modules.

UNREP of Marine Corps ordnance and stores introduces a new evolution for underway replenishments. Some of the Marine Corps ordnance and stores exceeds

Lieutenant Commander Jess Arrington, IPS Test Manager, inspects the Rolls Royce MT30, tested during 2006.
Photo courtesy of Gordon I. Peterson, Naval Forces Magazine.

INTEGRATED POWER (Continued from page 9)

load shedding is essential for system operation and equipment protection. In addition to the paralleling activities, the entire 4-MV switchboard ring bus was commissioned. This entailed coordinating the protection settings for dozens of circuit breakers. Protection settings for safeties such as over voltage, under voltage, over current, reverse power, etc., had to be verified prior to live test operations. Additionally, the controls and power management system had to be integrated with the IPS. Previously, the C&PM was utilized for remote operation and monitoring for the MTG and ATGs–now, the entire MV system can be interfaced with C&PM allowing for remote switchboard operation as well as generator mode selection and paralleling commands to be carried out.

Following this second commissioning phase, a series of system tests were conducted to characterize the IPS EDM and further reduce technical risk. Testing included system transient and load rejections, high-power operations, endurance operations, fault detection and recovery, casualty scenarios, and automated power management operations. Acoustic and magnetic signature data were also acquired to assist in model development and validation for the Flight 1 Ship design. The results from these tests will prove to be of great value during the detail design and construction phase of the program and will serve as a firm knowledge basis for future efforts including validation of DDG 1000 Flight 1 production hardware and software.

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the maximum lift capacity of the current 5,700-pound UNREP system. In anticipation of this new requirement, Strategic Mobility/Combat Logistics Division (OPNAV N42) initiated an RDT&E project with Port Hueneme Division, the Navy's UNREP center of excellence, to develop a significantly improved UNREP system, designated as Heavy UNREP. This system is being developed to support the future sea basing part of *Seapower 21*. Its purpose is to transfer twice as heavy loads at twice the speed and at a wider and safer ship separation. Heavy UNREP is projected to complete in FY 10 with an at-sea demonstration of the final design.

A special requirement for sea basing operations will be the medical evacuation of wounded Marines that cannot be quickly returned to duty. The wounded Marines will be in sea basing ship sick bays or in a hospital ship that is also part of the Sea Base. The only flights from a Sea Base ship to the Advance Base (that could be up to 2,000 miles away) would be the Carrier Onboard Delivery (COD) flights, which have limited capability. The HSVs could be used to shuttle patients to the Advance Base and could be temporarily fitted with modular sick bay units for the patients. A simple UNREP ambulance has been mocked up by Port Hueneme for transferring the wounded, four at a time, from Sea Base ships to the high-speed vessel. The transfer of the UNREP ambulance could be performed by VERTREP helos or by the same rig used for transferring Marines from high-speed vessels to Sea Base ships.

These concepts for the Navy's sea basing underway replenishment system continues Port Hueneme's long-standing commitment to sustaining and

SEA BASING (Continued on page 14)

CUSTOMER ADVOCACY

CURRENT AND FUTURE CARRIERS

Teaming to Ensure Solid Engineering for Aircraft Carriers

Above: Artist's rendering of the CVN 21 underway. The Future Carrier CA supports PMS 378 in all hull, mechanical, and electrical engineering aspects concerning CVN 21.
Graphic rendering provided courtesy of the Future Aircraft Carrier Program Office.

Left: USS Ronald Reagan (CVN 76). *Official Navy photo.*

Below: USS Ronald Reagan (CVN 76) underway. *Official Navy photo.*

Collage by Gloria Patterson, NSWC Carderock Division.

By Leslie Spaulding

The U.S. Navy depends on its aircraft carriers in times of global crisis, peacetime presence, and full-out war. The carrier mission is to provide a credible, sustainable, independent, forward presence and conventional deterrence in peacetime; to operate as the cornerstone of joint/allied maritime expeditionary forces in times of crisis; and to operate and support aircraft attacks on enemies, protect friendly forces, and engage in sustained independent operations in war. So ensuring that the carriers of today's Navy, as well as those of the Next Navy and the Navy After Next are well supported is paramount.

The Ships and Ship Systems (S^3) Product Area (PA) provides this stewardship through customer advocates (CAs) dedicated to two distinct functional areas–the In-Service Carriers CA, who focuses on the needs of the current fleet of carriers, and the Future Carriers CA, who supports the next generation. The CAs serve as liaisons between the customers and the department heads, core equity leaders, and technical personnel within the S^3 PA, ensuring the right work is being executed in the right place at the right time for the customer. Beyond meeting stated current needs, the advocates serve as stewards through business forecasting, working with the Program

Executive Office Aircraft Carrier (PEO Carriers) to see how the S^3 PA must focus its efforts to meet their needs further down the line.

"We interface between our customers outside of the product area and the technologists within the product area," explained Jim DiTaranto, the In-Service Carriers CA. "We adjudicate any problems either side might face, review tasking proposals to ensure they meet customer requirements, resolve customer complaints, and generally ensure that all parties agree with what needs to be accomplished and identify the best approach to execute the tasks. And we work to ensure that our business is focused on the future."

The In-Service Carriers CA supports PEO Carriers (PMS 312), which covers any carriers in the Refueling and Complex Overhaul (RCOH) or new construction phases, as well as carriers that are active in the fleet. The S^3 PA supports PEO Carriers in a variety of programs including Smart Carrier, distributed data control networks (DDCN), performance-based logistics opportunities, Carrier Obsolescence Strategy, and in-service engineering support of carrier-unique equipment such as aircraft elevators, O_2N_2 systems, JP-5 systems, and catapult accumulators. In collaboration with SPAWAR and Dahlgren Division, Carderock Division, under the S^3 umbrella, successfully led an effort on the DDCN to resolve interfacing issues with respect to navigation, communication, and machinery controls systems. Formerly known as integrated communications and advanced networks (ICAN), the system was restructured to improve the interface between the various systems, including navigation, ship control, machinery control, interior and external communication, the core network backbone, and associated power. The cross-PAD communication and teaming exhibited in this particular effort was paramount to its success.

Smart Carrier is another example of support provided across the S^3 PA, which involves a series of alterations conducted within an availability on in-service carriers. Smart Carrier incorporates automation of a number of systems, such as JP-5 system, list control, firemain control, advanced damage control system, and weapons elevators. The integration of these systems requires input and coordination across the S^3 PAD to meet the expectations of PEO Carriers.

The Future Carrier CA supports PMS 378, which is comprised of three major components–the Carrier Engineering Team (CET), the Live Fire Test and Evaluation (LFT&E) group, and the Advanced Technology Development and Integration Group. Under the umbrella of the S^3 PA, Carderock Division provides more than 25 people in disciplines ranging across the HM&E area from deputy ship design managers to system engineer managers to technical experts in support of CVN 78 and beyond.

Congress mandates that a LFT&E program be performed on all new ship designs. The focus of this program is to assess the vulnerability and survivability of these new designs. A major product of this support is the vulnerability analysis report on the future ship design. Carderock Division engineers serve an integral part in helping to meet the vulnerability and survivability requirements set out by the design by exploring improvements in areas of the ship's capabilities against potential underwater and air threats. In support of advanced technology, engineers supporting the S^3 PA are researching various technologies such as the plasma arc waste destruction system, which treats shipboard waste; the Autogrape system, which is a JP-5 monitoring system; smart stores; wireless sensing of elevators; and stronger, lightweight materials for aircraft carrier design.

"As customer advocates, we ensure the program managers are fully aware of all the capabilities of the S^3 PA and that our personnel within the product area are employed where the customer needs them," said Future Carrier CA Reid McAllister. "Through that effort, good stewardship of the carrier fleet is maintained."

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Currently, one or two personnel are transferred at a time by this tensioned wire rope system.

Port Hueneme Division has experimented with a six-man chair. It is feasible that a chair capable of transferring 10 personnel at a time could be used in the Sea Base mission.

An UNREP ambulance for four patients.

The UNREP ambulance could be used to transfer 100 patients per hour by tensioned wire rope rig.

The current system with carrier strike group ordnance loads up to 5,700 pounds.

The future Heavy UNREP system with USMC QuadCon load up to 12,000 pounds.

SEA BASING (Continued from page 11)

improving UNREP technology. The Port Hueneme Division's UNREP System Engineering Team serves as the Navy's sole steward of ship-to-ship UNREP expertise, maintaining the Navy's corporate knowledge in this area. The team consists of 40 engineers and technicians and 10 enlisted Sailors, who built the Navy's only UNREP Test Site which is used extensively to resolve in-service problems and test prototypes of a new UNREP System. The team performs a full-range of system engineering from concept formulation through design, test, fleet introduction, and life-cycle in-service support. The Ships and Ship Systems UNREP Team is a small organization with big responsibility determined to ensure the Navy's UNREP system works when needed and performs as planned, anywhere, anytime.

Within the S^3 PA, UNREP is part of the overall Warfare Center Material Handling and Transfer (MHAT) effort to promote collaboration and integration of operational logistics. The S^3 MHAT efforts were described in detail in the Summer 2005 issue of SEAFRAME.

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The current system with carrier strike group provisions.

The future Heavy UNREP system with USMC HumVee.

All photos above provided by NSWC Port Hueneme Division.

Advanced Lightweight Structural Systems

Using the Latest Material Technology for Our Forces Afloat

Structures & Materials

By Daniel Bruchman

Evolving military objectives needed to effectively combat the war on terror and support critical operations around the globe are dictating the need for a U.S. Navy fleet that is agile and flexible, can dominate the littorals, and can deliver the necessary firepower in a short time frame. These global needs, in turn, compel ambitious operational requirements for fleet vessels to have increased maneuverability, flexibility, speed, range, and payload that can only be achieved using advanced lightweight/high-strength structural and material technologies.

The Ships and Ship Systems (S^3) Product Area (PA) provides the expertise and technical knowledge regarding the development of high-strength/lightweight structures and materials for surface ship applications. These technical capabilities are resident at Naval Surface Warfare Center, Carderock Division (NSWCCD). Currently, efforts there under the S^3 Product Area Director (PAD) involve research and engineering support of numerous lightweight structure applications, including DDG 1000 topside design and analysis efforts, High-Speed Sealift (HSS) structural research and development tasks, structural oversight of the Littoral Combat Ship (LCS) program, and direction and test support to the Office of Naval Research's (ONR's) Composite High-Speed Vessel (CHSV) program.

This expertise is critical for ships that focus on faster and more efficient deployment of mission-ready forces and their essential support. High-speed "connectors" will provide transportation of combat cargo, equipment, aircraft, and personnel in maritime environments around the world. With shorter contingency planning times and often remote delivery locations, these fast, flexible assets will rapidly deliver essential combat assets to ships at sea, making them critical enablers of sea basing at the most remote locations.

To meet demanding emergent strategic sealift objectives, a HSS Technology Workshop was conducted at NSWCCD in 1997. Participants in this internationally attended workshop included U.S. military representatives, government laboratories, academia, and industry. The workshop highlighted the current state of the art and projected future capabilities of critical high-speed ship enabling technologies, of which high-strength, lightweight structural and material technologies were judged to be of paramount importance in achieving strategic sealift performance objectives.

Future Navy combatant designs are requiring significantly increased capabilities within very restrictive budgets. Preliminary design studies for various combatant programs concluded that structural weight fractions using traditional construction practices are too high and result in operational capabilities that do not meet requirements. In addition, ship life-cycle and acquisition costs using traditional construction practices are no longer affordable. The need for significant weight and cost savings as well as other benefits, such as signature reduction, is driving combatant designs to advanced lightweight/high-strength structures and materials.

STRUCTURAL SYSTEMS (Continued on page 16)

USNS Truckee (TAO 147) off the Newfoundland coast in 20-foot seas in 1985 during ASW exercises involving U.S. and Canadian Naval forces.
Photo by Edward Devine, NSWC Carderock Division.

The high-speed vessel ***Joint Venture*** (HSV-X1) moves through the waters off the coast of southern California. In 2002, ***Joint Venture*** participated in a fleet battle experiment bringing together both live field exercises and computer simulations throughout the Department of Defense.
U.S. Navy photo by Photographer's Mate 2nd Class Frederick McCahan.

HMS Helsingborg is the second of the ***Visby*** Class of Swedish Corvettes.
Photo by Peter Nilsson of Kockums AB (shipbuilder).

STRUCTURAL SYSTEMS (Continued from page 15)

Common to all lightweight structural designs is a requirement for a thorough understanding of the loads on the structure; otherwise a reliable, optimized design is impossible to achieve. Often, lightweight structures and novel hull forms are potential solutions to meeting ambitious operational requirements. Unfortunately, structural loads on these novel hull forms are largely unknown as they fall outside traditional experience, and current load prediction tools are limited in the ability to reliably ascertain these loads. Numerical simulations combined with model tests are necessary to estimate primary and secondary structural loadings to provide an efficient structural design.

The local components that comprise the hull girder for either traditional monohulls or more novel hull forms are subjected to global primary hull-girder loadings and/or local secondary loadings. There are more primary hull structural and material options available to the ship designer for smaller craft (less than about 120 meters) than for larger vessels. For the most part, near-term options available for large ship primary hull applications are limited to high strength steels. For ship hulls less than about 120 meters, the Navy is currently evaluating the suitability of several aluminum catamaran concepts, such as the HSV X1, the HSV 2, and the *Sea Fighter* (FSF 1), for military applications. In addition, an aluminum trimaran concept was recently selected for one of the two LCS variants. Similar designs have been used in the fast ferry industry and by DoD under restrictive service guidelines, but the ability of the vessels to operate without restrictions throughout typical Navy service lives has not yet been proven.

Composite structures and materials are also an alternative for near-term, primary hull applications below hull lengths of about 100 meters. Ships that are currently in operation and composed of composite materials include the *Osprey* (MHC 51) Class of mine hunters that uses a monocoque, E-glass, polyester material; the Swedish Corvette, *Visby*, that uses a sandwich construction consisting of a carbon fiber and vinyl laminate and a PVC core material; and the Norwegian surface effect ship (SES) *Skjold* that exhibits a sandwich composite E-glass vinylester construction. These ships represent the state of the art in composite primary hull applications.

For larger ships, near-term technology insertion candidates are largely limited to secondary structural applications, such as gratings and enclosures. Research and development efforts necessary to mature lightweight/high-strength technology insertion candidates for mid-term and far-term primary hull applications are being conducted in various ONR and DARPA initiatives and the HSS Technology Development Program. Recent advanced, lightweight composite secondary structural applications are being implemented throughout the fleet. Composite materials were also demonstrated in the Advanced Enclosed Mast/Sensor concept implemented on *USS Arthur W. Radford* (DD 968) and the advanced enclosed mast system for the LPD 17. Other composite topside applications necessary for weight and cost reductions were selected for high visibility applications. In general, these composite applications can provide 30% to 50% weight reduction as compared to conventional steel alternatives.

Titanium secondary structures are also being introduced in the fleet to reduce weight and maintenance costs. Applications include a door and a hatch on the DDG 51 and piping on the LPD 17, where weight savings up to 50% was anticipated and up to an 80% return on investment over the service life of the ship was projected. Potential CVN titanium applications include aircraft elevator doors, hangar bay division doors, and hatches and scuttles.

The development of high-strength/lightweight structural systems is essential to realize the ambitious speed, range, and payload goals of future non-combatant and combatant missions. Advanced composites, metallic sandwich type applications, aluminum alloys, and titanium structures can all play a role in providing substantial weight reductions in potential near-, mid-, and far-term ship applications. These technologies were used in various secondary structural applications throughout the fleet.

Technology insertion candidates and associated R&D needs for near-term applications are being addressed in various acquisition programs. Further development of these technologies is needed and infrastructure needs to be identified to provide more significant weight reduction for future mid-term and far-term concepts to extend the use of these concepts to primary hull applications.

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Environmental Quality Systems

Naval Vessel Rules for Shipboard Environmental Protection Systems

Ensuring Navy Ships Are Designed for Affordable and Mission-Compatible Environmental Compliance

Reprinted with permission from Currents Magazine, a Navy publication supporting the environment.

By Anthony T. Rodriguez

Afloat compliance with environmental laws, regulations, executive orders, international agreements, and host-country requirements is more than a legal mandate–it is vital if Navy ships are to maintain readiness and operate, train, and make port calls when and where needed around the world. Although environmental protection requirements apply to all naval platforms, the planned concept of operation, mission capability and duration, and manning level help determine the type and level of pollution abatement capability that any single platform must possess.

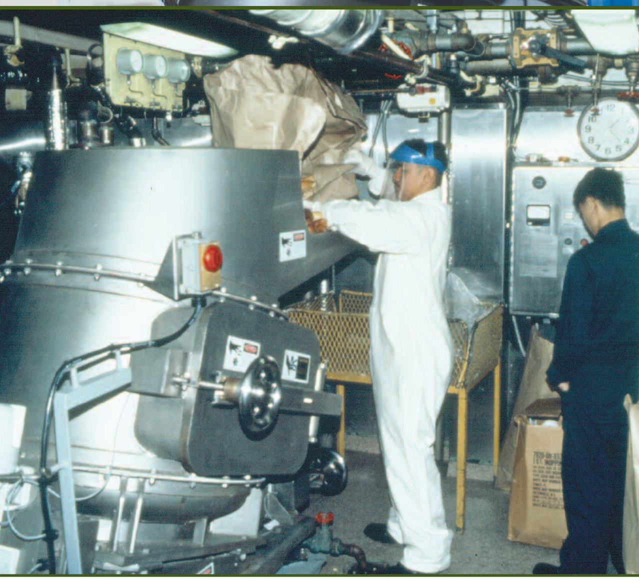
To this end, the Naval Vessel Rules (NVRs) governing environmental protection systems were developed to enable the Navy and contract design agents to tailor the level of pollution abatement capability of a new platform to match its mission and planned concept of operation. The NVRs also enable the Navy to apply a fleet-wide perspective to establishing a platform's environmental requirements and to designing shipboard environmental equipment and systems through the use of common shipboard environmental solutions coupled with the appropriate degree of standardization.

The Naval Sea Systems Command's (NAVSEA's) Ship Environmental Engineering Division (SEA 05M4) is the Command's Technical Warrant Holder (TWH) for Environmental Systems and Materials Engineering Ships. In this role, it has review and approval authority for the design, installation, and operational certification of shipboard environmental equipment, systems, and

NAVAL VESSEL RULES (Continued on page 18)

Left: NSWC Carderock Division engineer Barry White, left, explains pulper demonstration hardware to coworker Henry Molintas, as part of informal mentoring which advances stewardship of capabilities.
Photo by James Contreras, NSWC Carderock Division

Below: The large pulper installation on ***USS George Washington*** (CVN-73). Detailed design guidance for the pulper as a solid waste management option for implementation aboard large ships is provided in the NAVSEA Design Supplement that corresponds to Naval Vessel Rules for Paper and Cardboard Waste.
Photo courtesy of the Environmental Quality Division, NSWC Carderock Division.



A Sailor loads the pulper onboard the LHD 1. Decades of Navy laboratory and at-sea experience with environmental systems, including the solid waste pulper, are incorporated in Naval Vessel Rules and their companion NAVSEA Design Supplements.
Photo courtesy of the Environmental Quality Division, NSWC Carderock Division.

NAVAL VESSEL RULES (Continued from page 17)

management practices. To facilitate technical authority execution of environmental solutions for new construction ships, NAVSEA has included performance and design rules for environmental protection systems in the NVRs it is developing in conjunction with the American Bureau of Shipping (ABS) for non-nuclear surface combatants (ABS NVR 5.7.1 18). The Naval Surface Warfare Center, Carderock Division (NSWCCD), as an integral component of the TWH's pyramidal organization, partnered with NAVSEA in the development of the NVRs and associated technical documents. NSWCCD engineering agents and lead engineers support NAVSEA's technical authority process with environmental systems expertise, engineering data, in-service experience, and fleet lessons learned.

The NVRs establish performance requirements for the shipboard management of waste streams and hazardous materials. They identify the top-level legal and policy drivers for shipboard control of regulated discharges; provide basic system performance and design objectives for the collection, storage, processing, and retrograde of the wastes; and incorporate the requirement for operational certification. For each waste stream, the NVR will invoke a companion NAVSEA Design Supplement (NDS) that provides detailed design, engineering, integration, and installation guidance. The NDSs reflect decades of Navy laboratory and at-sea experience with environmental systems, timely technology assessments of commercial marine environmental products, and the lessons learned across different types of ships and operating scenarios. This ensures the level of stewardship of capabilities remains high. Together, the NVRs and associated NDSs represent a centralized record of environmental requirements and engineering experience for new and legacy ships.

During NVR development, attention was focused first on those waste streams for which NAVSEA 05M4 is responsible, and then on those covered by warrants external to NAVSEA 05M4. The latter are typically hull, mechanical, and electrical (HM&E) systems and propulsion systems, the operation of which have environmental consequences and will be addressed in separate NAVSEA design guidance documents. The NVR and NDS for each waste stream contain complementary sections on requirements, system design, and certification. The system design sections of both documents contain information on waste sources and composition; waste generation and design rates; and requirements for collection, processing, storage, and retrograde to shore. NVRs for the management of plastics waste, paper and cardboard, metal and glass waste, food waste, blackwater, graywater, bilge water and oily wastewater, and hazardous materials are just a few of the ship waste streams that have been addressed.

New NVRs and NDSs will be created for other waste streams as legal and policy requirements dictate. For example, deck runoff and gas turbine water wash are wastes that will be subject to new Uniform National Discharge Standards (UNDS) regulations being jointly developed by the Department of Defense (with Navy lead) and the Environmental Protection Agency. In addition, the NVRs and NDSs will address cross-functional environmental systems, such as the thermal destruction of solid and liquid wastes.

Several ship acquisition programs have already benefited from the application of NVR and NDS documents. DDG 1000, LCS-Lockheed Martin, and LCS-General Dynamics are following the NVR guidelines. Other programs, including LHA(R), CVN(X), and DDG 51 Class, are benefiting from the environmental guidance and engineering details these documents provide as a central reference resource. As commercial shipbuilding practices and commercially available environmental equipment and systems become more widely adopted for the construction of naval vessels, the reliance on NVRs will increase. The NVRs and NDSs–in conjunction with NAVSEA's technical authority review, approval, and certification processes–will provide consolidated and validated performance and design requirements upon which ship designers and builders can confidently create detailed specifications and designs.

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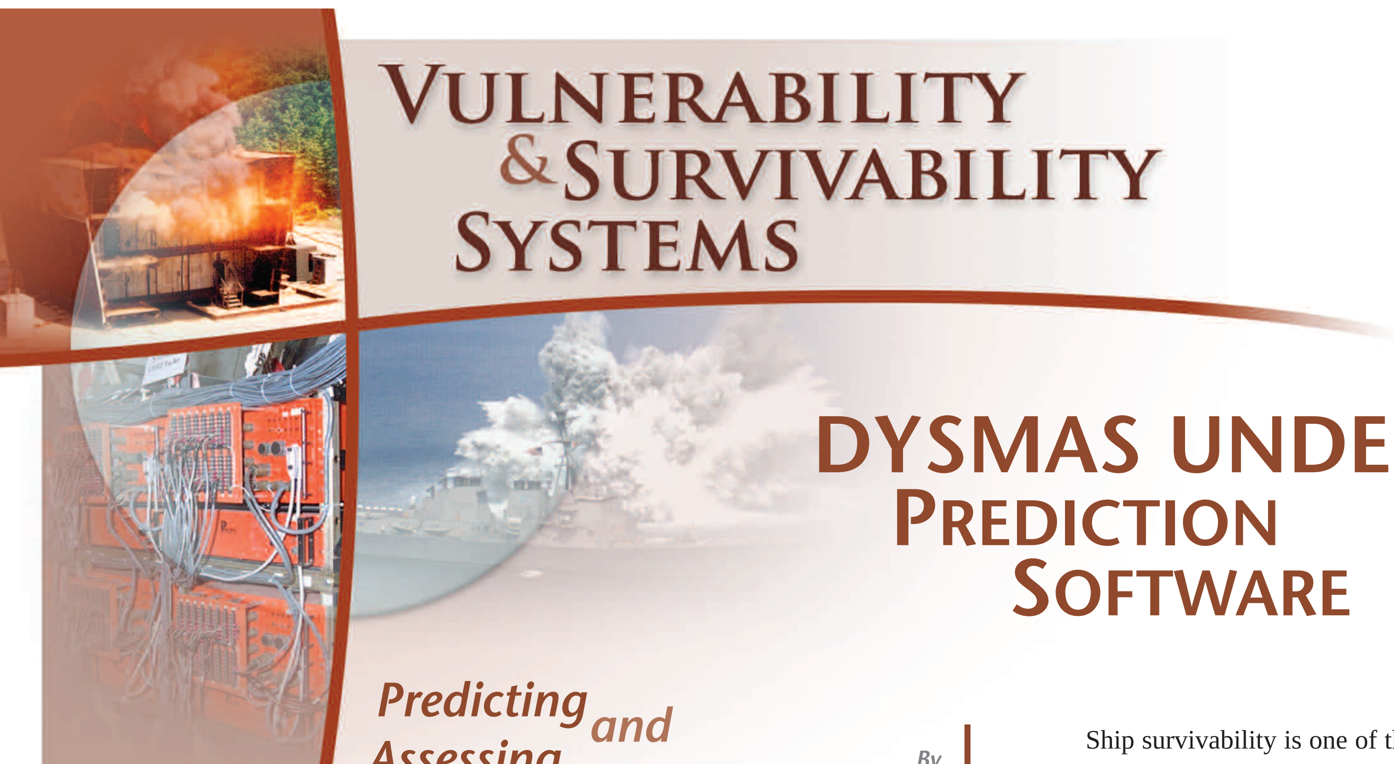


VULNERABILITY & SURVIVABILITY SYSTEMS

DYSMAS UNDEX PREDICTION SOFTWARE

Predicting and Assessing Survivability and Weapons Effects Using Simulation Tools

By Lawrence F. Ripley, Frederick A. Costanzo, and Gregory S. Harris

Ship survivability is one of the key attributes that separates Naval ships and submarines from commercial vessels. Because these platforms must be capable of operating in hostile environments, it is critical that the Navy be able to accurately assess and ensure their survivability.

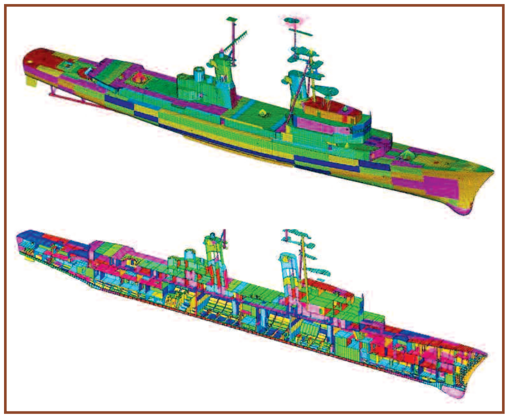
DYSMAS UNDEX (Continued on page 20)

DYSMAS UNDEX (Continued from page 19)

Predicting the survivability of ships and submarines to underwater explosions (UNDEX) was very limited prior to WWII. There was little understanding of UNDEX and predictions were based on formulas and model testing. Through the 1960s, new theories were developed to predict the mechanisms of underwater explosions and associated ship or submarine responses. The computer age then brought with it major advances in the ability to understand the phenomenology and the effect on shipboard structures and systems.

One of these advances is a computer code titled "Dynamic System Mechanics Advanced Simulation" or DYSMAS. DYSMAS is a fully coupled hydrocode used to analyze the highly dynamic response of ship and submarine structures exposed to weapons effects loads. The development of DYSMAS began in the late 1970s under the guidance of the German Ministry of Defense. The United States Navy became interested in DYSMAS in the late 1980s, and in 1993, a memorandum of understanding was signed between Germany and the Office of Naval Research (ONR), which provided the DYSMAS code to the United States for evaluation. In 1996, the United States and Germany signed a project agreement to further develop DYSMAS, under the leadership of NSWC Indian Head.

Over the last decade, NSWC Carderock Division and Indian Head Division (IHD) collaborated on the development and use of the DYSMAS computer code. Carderock focused on using DYSMAS to evaluate ship vulnerability and to develop advanced protection measures, while Indian Head worked on developing improved warheads and underwater weapons. During that time, DYSMAS was used to analyze UNDEX weapons effects for a variety of different applications including ship design, analyses of alternatives, and Live Fire Test and Evaluation programs to assess the performance of the new designs to realistic combat environments. DYSMAS simulations also enhance the development of UNDEX resistant hull structures, including concepts that are well beyond the predictive ability of historical empirical databases.



Finite element representation of German destroyer to be tested.
Graphic provided by Matthew Grassman, NSWC Carderock Division.

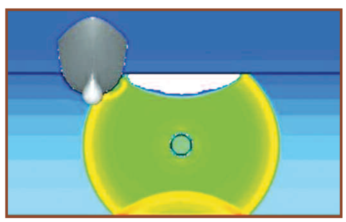
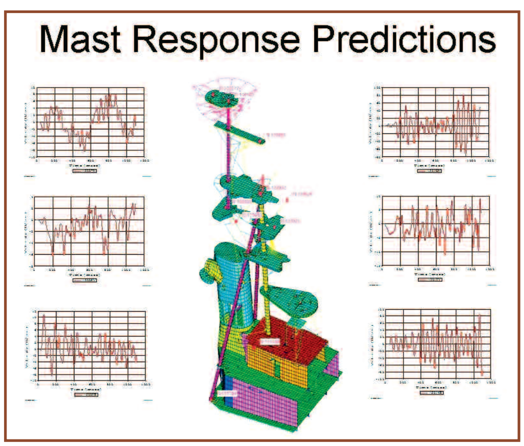


Illustration of the simulated shock wave propagation showing interactions with the sea bottom.
Image provided by Roger Ilammi, NSWC Indian Head Division.



Example of typical predictions to be compared with measured data.
Graphic provided by Peter D. Loeffler, NSWC Carderock Division.

NSWCCD and IHD engineers support an ongoing project agreement with Germany to conduct an UNDEX trial against a decommissioned German destroyer. This test program will gather data necessary to validate DYSMAS for full-scale ship response applications. In late spring 2006, engineers and technicians from the two Warfare Center divisions traveled to Germany to support the trial. A full range of UNDEX loading conditions will be tested, beginning with traditional ship shock test geometries and concluding with realistic weapon attack geometries. Data will be collected from this test series and compared to pre-test predictions. The graphics accompanying this article pertain to these tests.

The development of DYSMAS resulted from effective teaming between the NSWCCD and IHD. The successful integration of the needs of the two organizations produced a simulation tool that is now the Navy's choice for assessing UNDEX effects on Naval targets, including ships, submarines, torpedoes, and mines–for both defensive and offensive applications.

Stewardship of this knowledge area is the responsibility of NAVSEA Headquarters, Warfare Center Ships and Ship Systems (S^3) Product Area (PA), and the two NSWC divisions. In today's environment, an instrumented ship UNDEX test series is not a common event. Rather, it provides a rare and important opportunity to mentor young engineers in ship survivability research, analysis, instrumentation, and testing. Only through capitalizing on opportunities like this can we assure a successful and complete transition of our technical expertise in the survivability and weapons effects area, as well as ensure continuity into the future. These young engineers who benefit from such mentorship, represent the next generation of survivability engineers for the Navy.

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Signatures, Silencing Systems, & Susceptibility

ARD Stewardship

Advanced Electric Ship Demonstrator, *Seajet,* underway for testing at ARD.
Photo by Billy Boston, NSWC Carderock Division.

Transforming to Support Advanced Ships that are Innovative, Adaptable, and Affordable

By Henry Netzer

The Acoustic Research Detachment (ARD) in Bayview, ID, is undergoing significant changes to support the vision to “Ensure U.S. Naval supremacy. …” The ARD transformation addresses future

ARD STEWARDSHIP (Continued on page 22)

ARD'S research vessel ***Whitefish*** in drydock. ***Whitefish*** is one way ARD maintains a high level of expertise in acoustic research.
Photo courtesy of John Suiter, NSWC Carderock Division Bayview.

ARD STEWARDSHIP (Continued from page 21)

Navy needs that include development of high-speed, maneuverable, and all-electric ships. To retain this capability, ARD must be affordable. ARD is accomplishing this transformation through capital improvements, the Lean process, workforce reconfiguration, and new work collaborations.

ARD is located on Lake Pend Oreille, a deep, cold-water lake in northern Idaho with ideal acoustic conditions. The facility played a part in developing every major U.S. submarine quieting improvement in the past 40 years.

The *Kokanee* and *Cutthroat* powered models are adaptable test platforms that support the evaluation of submarine systems prior to full-scale implementation. Demonstrations of development models on these vehicles directly contributed to *Seawolf* and *Virginia* Class propulsors, new sail, flow noise, and cost reduction initiatives.

The Intermediate Scale Measurement System is the premier facility in the world for conducting structural acoustic measurements. Pressure hull models allow for static testing of hull treatments, internal decks, and machinery supports. Model testing made significant contributions to stealth technology and cost reductions in submarine design.

ARD was actively involved in improving the performance of current and future sonar systems using buoyant models, which led to significant improvements in sonar self-noise on *Virginia* and *Seawolf*. Sensor improvements were realized as a result of ISMS tests conducted on conformal sonar array systems. ARD also uses a 60-foot test platform to conduct towed array sonar testing.

Over the past 40 years, the U.S. Navy has developed ARD from a remote mountain lake to a unique test facility offering near-ideal environmental conditions and a wide range of measurement and test capabilities.

Infrastructure investments and development of test and analysis methods have created the Navy's comprehensive test resource for all hydro-acoustic evaluations. ARD was arranged to provide a high tempo, rapid response to the demands of individual program customers and offers excess capacity for the envisioned future work. The Navy faced formidable questions about ARD: how should this unique resource be used to meet the new needs of the Navy?

ARD is reinventing itself to meet greater, more diverse technology requirements without sacrificing the technical capability it developed over the last 20 years. To be a good steward of this national asset, ARD must continue to work to satisfy the Navy's requirements to help "ensure U.S. Naval supremacy through advanced ships and ship systems that are innovative, adaptable, and affordable."

Several initiatives formed the foundations for fundamental changes, including changes in work processes and efforts to diversify customer bases.

Work process changes started with the *Core Equities/Critical Health Assessment*: this 2002 review emphasized the personnel to meet the mission. For ARD to continue meeting scheduled testing, it tailored its workforce to critical mission skills. This was followed by a coordinated Lean approach to implement the changes necessary to transform the organization. "Stovepipes" of well-trained, experienced crews were reassigned for greater flexibility. ARD staff evaluated every process, position, and system; examined maintenance, logistics, software, and sensor processes; and produced changes in every area. The implementation of Lean was challenging, uncomfortable and imperfect–the core of organizational realignment. One aspect of Lean was Workforce Integration, a six-month project to integrate the ARD workforce. This eliminated barriers at all levels and followed the analysis, which showed common project requirements. Looking to existing customers was not

Research vessel ***Cutthroat*** (LSV2) on Lake Pend Oreille.
Photo courtesy of Alan Griffitts, NSWC Carderock Division Bayview.

sufficient to maintain capabilities. By seeking a broader customer base, ARD can maintain its technical expertise.

Customer expansion included new and far-reaching collaborative arrangements with the University of Idaho. First is the application of existing systems for use with multiple autonomous underwater vehicles. In addition, ARD initiated new technology demonstration in areas of electromagnetic and power electronics. Teaming with the NSWCCD Philadelphia site, ARD is using large models to demonstrate advanced electric ship technologies. The Advanced Electric Ship Demonstrator, *Seajet*, has opened opportunities for the multi-spectral evaluation of surface ship signatures, including IR, RCS, acoustics, underwater magnetics. The quiet acoustic conditions at Lake Pend Oreille, along with the fully capable test platforms at ARD, enabled the establishment of a sensor calibration capability. ARD expanded its successful role in towed array evaluation to include calibration and performance testing. As ARD managers continue to explore new projects and collaboration opportunities, the capabilities of local technology partners and universities continue to surface with applicable research and manufactured products.

Throughout all these reviews and changes ARD maintained the posture as the premier and preferred full service hydro-acoustic test facility.

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TECHNOLOGY & INNOVATION

Mentoring of Young Engineers Pays High Dividends

RAPID RESISTANCE EVALUATION OF HIGH-SPEED SHIPS

By Gabor Karafiath and Bryson Metcalf

Under the supervision of Gabor Karafiath, Naval Surface Warfare Center Carderock Division junior engineers Bryson J. Metcalf and John Grabeel developed the Total Ship Drag (TSD0) prediction tool. This work was supported through the Independent Applied Research (IAR) program, which was initiated to develop junior engineers in key areas of expertise within NSWCCD. At Carderock Division, the IAR is focused on critical research issues in the Ships and Ship Systems (S^3) Product Area (PA) with an emphasis on collaboration and mentoring of young investigators. Each IAR project is aimed at filling recognized technology gaps while enabling the Navy after Next. This IAR project was part of a focused effort on high-speed ships that has been completed. Current initiatives include projects on topside signatures and structures integration and reducing slamming loads on high-speed small craft.

This effort focused on identifying a quick and robust computational tool capable of predicting the total resistance of many types of high-speed ships that are of interest to the Navy. The state of the art of viscous flow free surface CFD (computational fluid dynamics) flow codes is such that they tend to be too time consuming and expensive for use during the current source selection/design evaluation process. Therefore, based on the experience of the investigators, an analytical program utilizing the potential flow code FKS0, for predicting wave drag, was selected to be the most appropriate prediction tool for high-speed hull forms. Carderock Division researchers Dr. Dane Hendrix and

RAPID RESISTANCE (Continued on page 24)

Gabor Karafiath, right, points out waterjet design to Bryson Metcalf. Collaborative efforts have resulted in a quick and robust computational tool capable of predicting the drag of many types of high-speed ship designs.
Photo by Martin Sheehan, NSWC Carderock Division.

RAPID RESISTANCE (Continued from page 23)

Dr. Francis Noblesse assisted in combining the FKS0 code with analytical and semi-empirical relations for the remaining drag components, creating the TSD0 code, which predicts total ship drag. TSD0 meets the needs for a fast and robust high-speed resistance prediction tool for use in preliminary/conceptual design evaluation.

The capabilities of TSD0 were proven through many comparisons of predictions to model resistance tests. Total resistance predictions were made for all 27 Series 64 high-speed monohulls and 60 Hyundai super-high-speed monohulls. These two sets of data represent high-speed resistance over a wide variation in hull form. In addition, resistance predictions were made for catamaran, trimaran, and swath type ships, including wave-piercing bows. In total, TSD0 resistance predictions were compared with model test data on over 100 different hull forms.

Using TSD0, six different drag coefficients were developed from prediction data, which were then summed together to represent the total drag coefficient. Of the six coefficients, the friction component was shown by far to be the largest drag component, with wave drag the second largest. Subsequent total drag coefficients were developed for a hull with a 40% transom, and also a full-depth transom, a multi-hulled vessel, a hydrofoil small waterplane area ship (HYSWAS), and a double-ended canoe shape.

Additional work began on improving the TSD0 code by accounting for the effects of craft speed on vertical center of gravity rise, or sinkage, and trim angle on high-speed hull forms. Initial results of the sinkage and trim predictions are very promising and indicate that the TSD0 code should routinely include the effects of sinkage and trim on the predicted resistance. In addition, the TSD0 code was expanded to include the capability for evaluating air-cushion supported hull forms. Future efforts are necessary to more adequately handle air cushion support and partial hydrofoil support and evaluate the capability.

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Ship Integration & Design

This core equity applies specialized expertise for surface and undersea vehicle design including early concept development, assessment and selection of emerging technologies, integration of selected technologies into optimized total vehicle designs, and evaluation of those technologies and designs for cost, producibility, supportability, and military effectiveness.

Machinery Systems

This core equity provides full-spectrum technical capabilities (facilities and expertise) for research, development, design, shipboard and land-based test and evaluation, acquisition support, in-service engineering, fleet engineering, integrated logistic support and concepts, and overall life-cycle engineering.

Hull Forms & Propulsors

This core equity provides the Navy with full-spectrum hydrodynamic capabilities (facilities and expertise) for research, development, design, analysis, testing, evaluation, acquisition support, and in-service engineering in the area of hull forms and propulsors for the U.S. Navy.

Vulnerability & Survivability Systems

This core equity provides full-spectrum capabilities (facilities and expertise) for research, development, design, testing, acquisition support, and in-service engineering to reduce vulnerability and improve survivability of naval platforms and personnel.

Environmental Quality Systems

This core equity provides facilities and expertise for research, development, design, human systems integration, acquisition support, in-service engineering, fleet support, integrated logistic concepts, and life-cycle management resulting in mission compatible, efficient and cost-effective environmental materials, processes, and systems for fleet and shore activities.

Signatures, Silencing Systems, & Susceptibility

This core equity specializes in research, development, design, testing, acquisition support, fleet guidance and training, and in-service engineering for signatures on ships and ship systems for all current and future Navy ships and seaborne vehicles and their component systems and assigned personnel.

Structures & Materials

This core equity provides the Navy with specialized facilities and expertise for the full spectrum of research, development, design, testing, acquisition support, and in-service engineering in the area of materials and structures.

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